LOW COST CRUISE MISSILE DEFENSE (LCCMD)

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This presentation discusses a program started last year to explore low cost approaches to dealing with a proliferated, low technology, cruise missile threat. You may be wondering why this briefing is part of the minimally manned systems section, and furthermore why is a Sensor Technology Office program manager the presenter. As you'll see when I discuss the concepts which are under evaluation, minimally manned systems may play a significant role in Low Cost CMD architectures. Also, as any air defender knows, particularly those who have worked the interceptor side of the problem, sensors/guidance sections can be significant cost drivers. Therefore, part of this program is to explore low cost seeker approaches to countering the threat I'm about to describe.

AGENDA

- Threat
- Program Objective/Philosophy
- LCCMD Approaches
- Industry Opportunities

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I'll begin by describing the threat in the context of a broader threat category that I call "asymmetric threats." I'll then describe some specific attributes of the cruise missile threat, followed by the program objective and our approach toward meeting that objective. I'll then review the three LCCMD architectures which are currently being studied and a couple of innovative low cost seeker approaches which not only show promise for this application, but may prove to have much broader applicability. Finally, I'll close with a few words on future industry opportunities.

"ASYMMETRIC" THREATS

Low Cost, Low Technology Means of Jamming Critical Military Systems and Delivering Large Numbers of Weapons

- Deny or Degrade Information Dominance
- Do Politically and/or Militarily Significant Damage

Ground Jammers (SAR, Surveillance, GPS), UAVs (Comm/Radar Jamming, Weapon Delivery), and Cruise Missiles (Weapon Delivery)

South African ARW-10 "LARK"

Chinese C-802 (Zhuhai Air Show)

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There are many different definitions of "asymmetric threats." My definition is stated on this chart as low cost, low technology means of jamming critical military systems and delivering large numbers of weapons. The first objective of employing such systems is to deny or degrade an adversary's ability to establish and maintain information dominance. Or, if you like, to thicken the "fog of war." The second objective is to inflict significant military or political damage. This encompasses a range of possibilities from isolated, small scale incidents to coordinated large scale attacks. A range of low cost platforms can be employed to carry out such missions from ground jammers, to UAVs, to cruise missiles. Countering ground jammers and UAVs poses significant challenges, but the subject of this briefing and this program is countering the low cost cruise missile. However, as I'll point out later, STO is interested in low cost seeker concepts to counter this whole range of threats. Now, let's turn our attention to the cruise missile threat.

CRUISE MISSILE EVOLUTION

THEN . . .

Vergeltungswaffe Eins
(Revenge Weapon One or V-1)

- 10,000 Launched Over 9 Months
- 250 Km Range, ~1900 lb Warhead
- Very Simple/Low Cost

NOW . . .

- Over 70,000 Worldwide
- Key Technologies Proliferating Rapidly (Propulsion, Guidance, Airframe, Warheads
- Longer Range, Lower Altitude, Smaller Signature, Greater Precision

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Cruise missiles have been with us for quite a long time, in fact the early work in cruise missile development started around World War I. They made their debut in battle during World War II when the Germans developed and deployed the V-1. The picture on the upper right side of the chart is the V-1 assembly line. The V-1 is a fascinating case study for those who want to understand the history of cruise missile development and their potential for rapid development and deployment. It was a very simple and effective weapon. Made of sheet metal and plywood and employing a pulse jet engine which ran on low grade gasoline, it was able to carry a 1900 pound warhead to 250 km. In one 9 month period, over 10,000 V-1s were launched at London, causing approximately 45,000 casualties. After the first six weeks of attack, the British anti-aircraft defenses became fairly proficient at negating the V-1, but that required large scale deployments. It is estimated that the cost of defending against the V-1, excluding the cost of the damage, was four times that of the German program.

Cruise missile technology has proliferated rapidly in the recent past and continues to do so. Over 50 countries operate cruise missiles, with a growing number of countries possessing indigenous production capability. It is estimated that 70,000 cruise missiles are in the world's inventory. The majority of those are anti-ship cruise missiles, but the prospects for land-attack conversion are great. Additionally, the explosion of guidance technologies (GPS/INS systems), increasingly efficient propulsion systems, and advanced airframes make today's version of the V-1 much more precise, lower flying, and longer range.

LCCMD THREAT

Baseline Vehicle

- Land Attack, Long Range (Up to 750 km)
- Low Altitude (100 m)
- High Subsonic Speed (Mach 0.6 - 0.9)
- Moderate Observables
- No Reactive Maneuver or ECM

Deployment Options

- Dense Raids Compressed In Time and Space
- Sparse Raids Over Large Geographic Area and Long Time Period

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The baseline attributes of the LCCMD threat are listed on this chart. Of primary interest is the land attack cruise missile threat with a range on the order of 500 to 750 km, fairly low flying, high subsonic speeds, moderate observables, and no reactive countermeasures. This is the baseline vehicle, with speed, maneuver, and ECM excursions being considered for robustness evaluation. The scenario of interest in this program is dense raids compressed in time and space. Raids on the order of 100 or 200 cruise missiles are being evaluated in Northeast Asia and Southwest Asia scenarios.

PROGRAM MOTIVATION

U.S. Has Effective Multi-Tiered Defense Components Capable of Countering A Proliferated Cruise Missile Threat

But That Effectiveness Comes At A Cost

- Requires maintaining large numbers of airborne assets on station and/or populating large areas with ground-based systems
- Draws valuable resources from missions only they can perform
- May have to increase inventory of relatively expensive launchers and missiles

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The individual cruise missile threat that I outlined in the last chart is certainly within the performance envelope of current air defense components. However, defense against a proliferated, dense threat would come at a cost. First off, large numbers of assets would need to be kept on station. Many of the assets one might use to counter this threat are uniquely qualified to perform other missions and one would like to preserve them. Those assets also tend to be relatively expensive. For very large raids, the inventories of expensive missiles and launchers might need to be increased. A low cost option, which preserves other valuable resources, is highly desirable.

OBJECTIVE

Develop Low Cost Cruise Missile Defense System and Components To Defeat Proliferated CM Threat

- Take advantage of new technologies to reduce cost
- Leverage current and planned Service platforms

Must Be Substantially More Cost Effective Than Proliferating Current And Planned Weapon Systems

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The objective of the LCCMD program is to develop low cost systems and components to defeat the proliferated cruise missile threat at a substantially lower cost than simply proliferating current and planned weapon systems. By substantial, I mean that a factor of 1.5 is unsatisfactory but a factor of 10 is of interest. Numbers in between may or may not be of interest depending on a number of factors including ancillary benefits, technical feasibility, robustness, etc.

PROGRAM PHILOSOPHY

Primary Emphasis On Interceptor, but . . .

Proposed Interceptor Must Be Integrated Into A Weapon System Concept

- Metrics are weapon system cost-per-kill and investment, not interceptor vs cruise missile cost exchange ratio
- Proposed concepts must address all aspects of typical air defense systems
  - Weapon system connectivity, CONOPS, O&S Costs, etc.

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The focus of the program is on interceptors and interceptor technologies; however, each approach has to hold together and meet the low cost criteria at the weapon system level. Exchange ratio metrics may not be sufficient to justify the development of a new interceptor. Therefore, investment and cost-per-kill metrics have been adopted at the weapon system level. To qualify as a viable low cost CMD approach, concept evaluations must address the full spectrum of weapon system issues from device feasibility, sensor performance, weapon system connectivity, CONOPS, and investment/ life-cycle cost to force-on-force performance.

LCCMD PROGRAM STATUS

Three Concept Development Contracts (One Year Duration) Awarded In January 1997

- Evaluating total investment requirements and cost-per-kill performance
  - LCCMD mix versus proliferation of current/planned systems
- Establishing technical and cost feasibility
- Examining robustness (weather, maneuver, etc.) and potential ancillary benefits

Potential Demonstration Phase To Follow

- May include all, none, or parts of each of the concepts proposed during concept development phase
- Potential four year effort with demonstration in FY01

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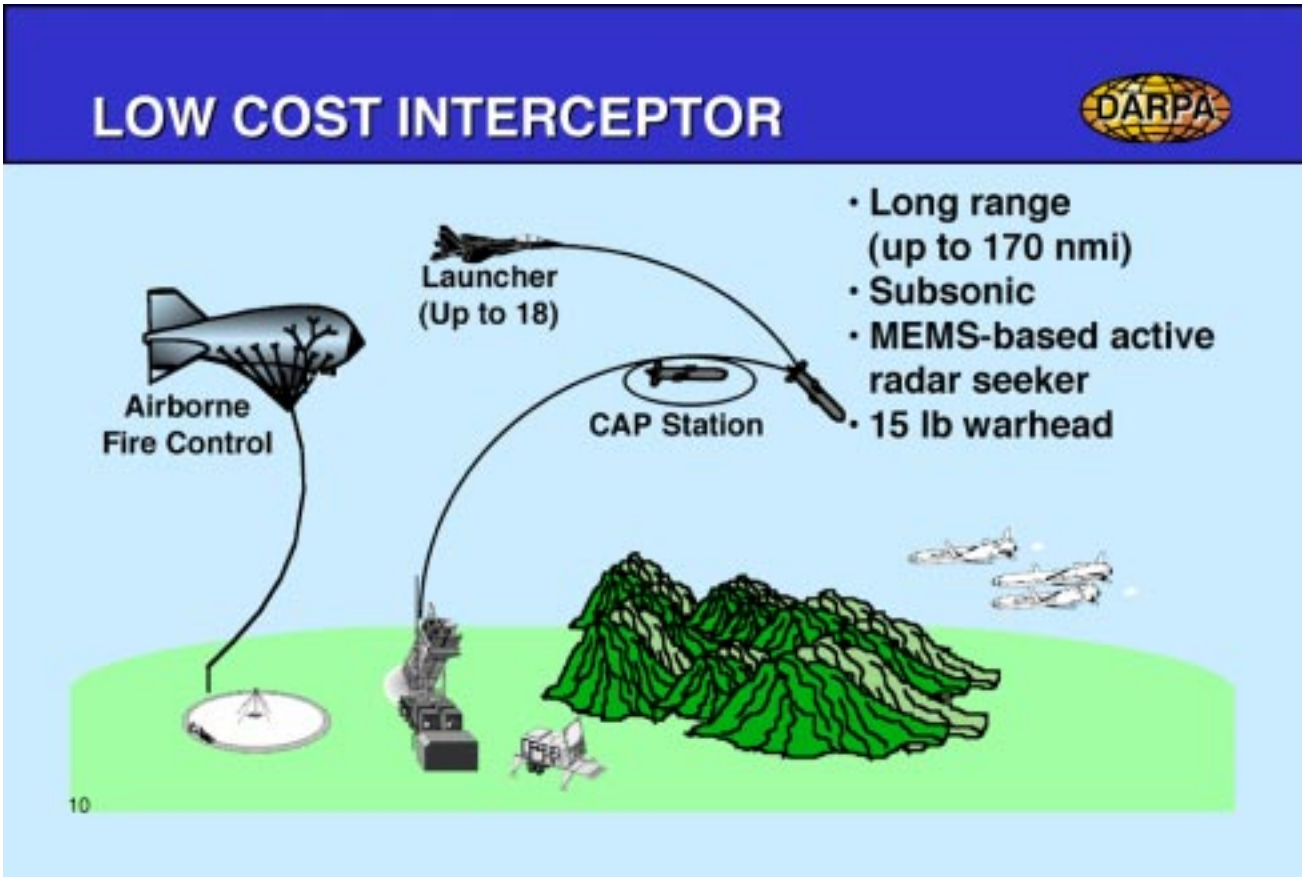
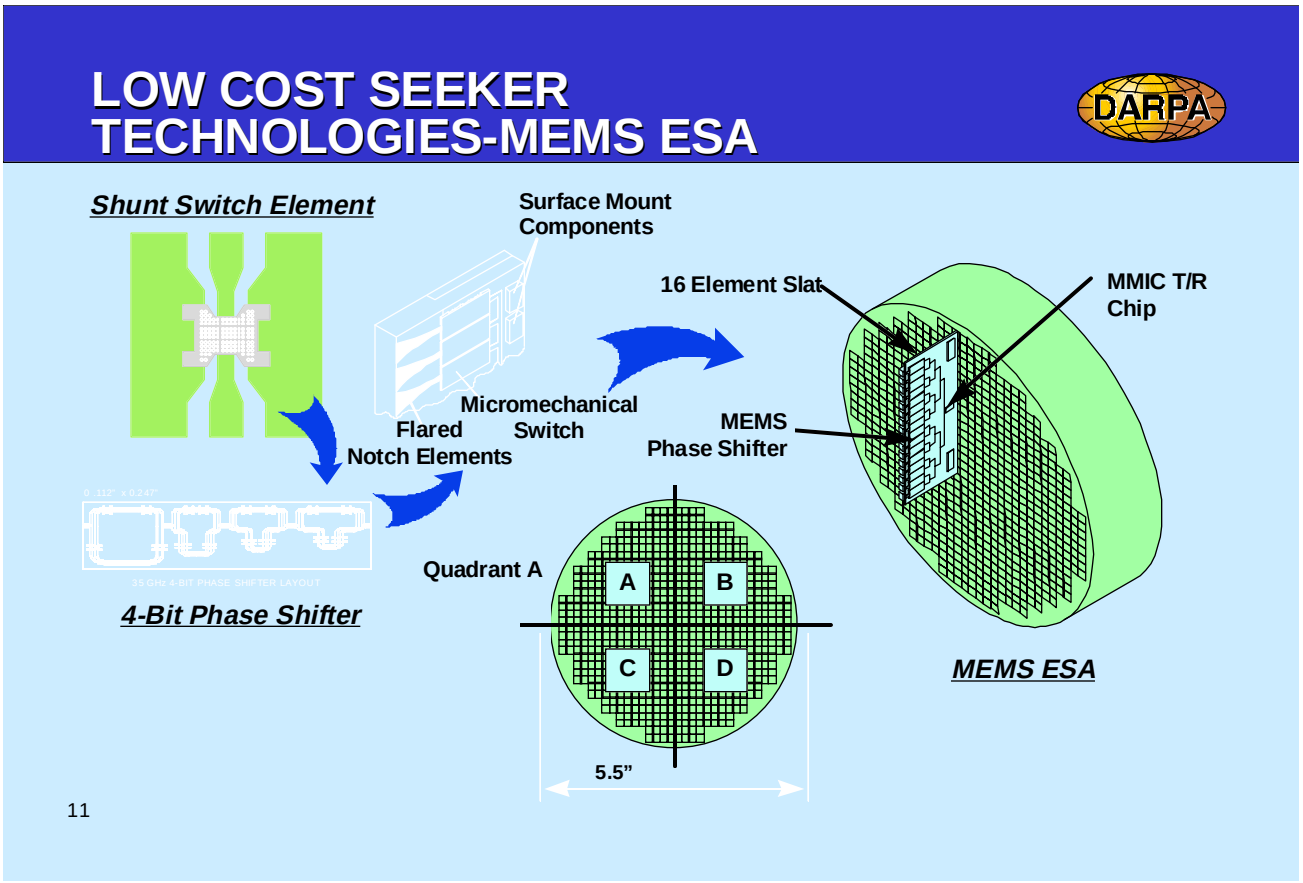
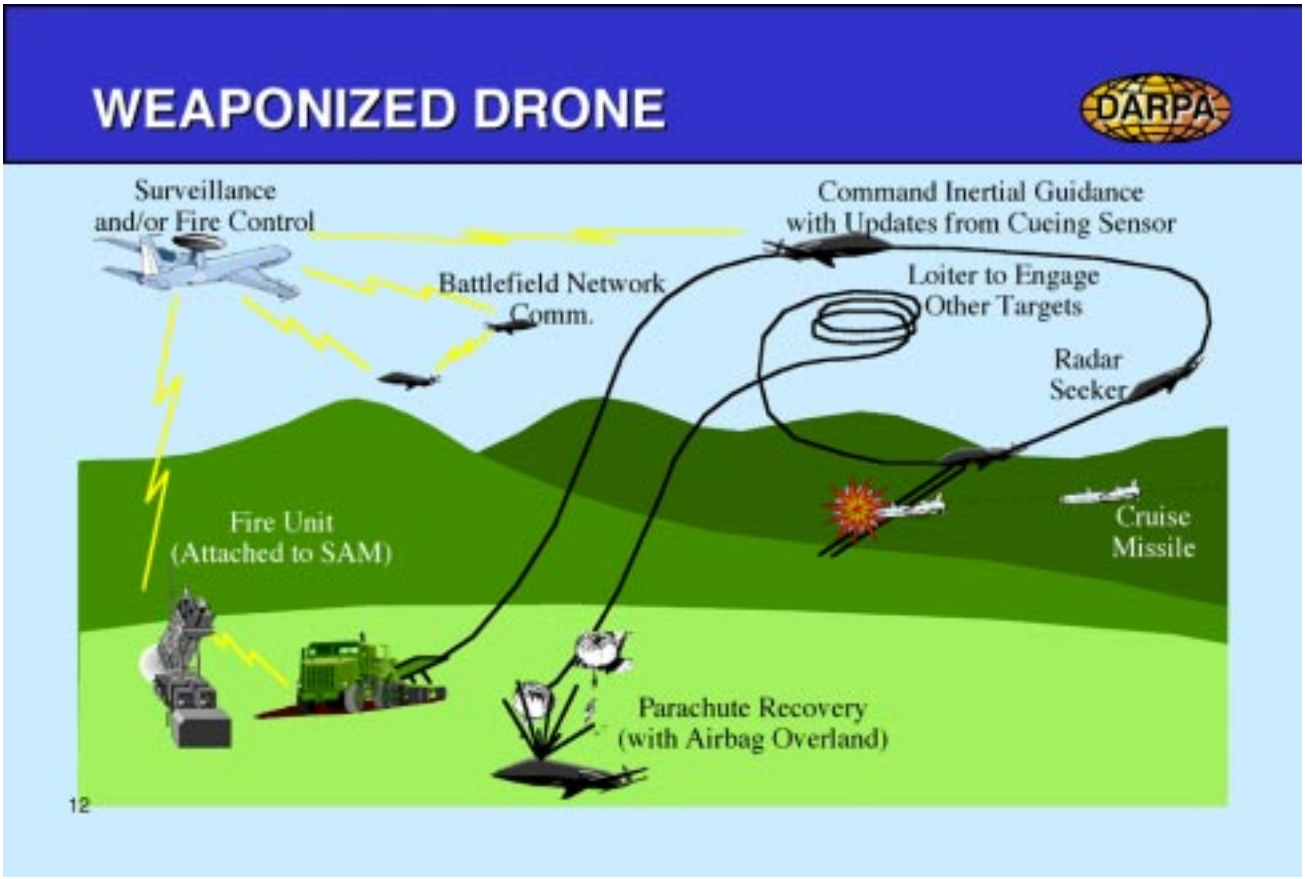
We are currently in the process of exploring three approaches. Concept development contracts were awarded for one year in January. It is too early to say, but if at the end of this phase we find a concept or concepts which appear promising, we may embark on a demonstration of one or more of the concepts or pieces of concepts. If so, I envision a four year effort culminating with a demonstration in 01, or perhaps a smaller, shorter duration effort if only a particular component, such as an antenna, is chosen for demonstration.



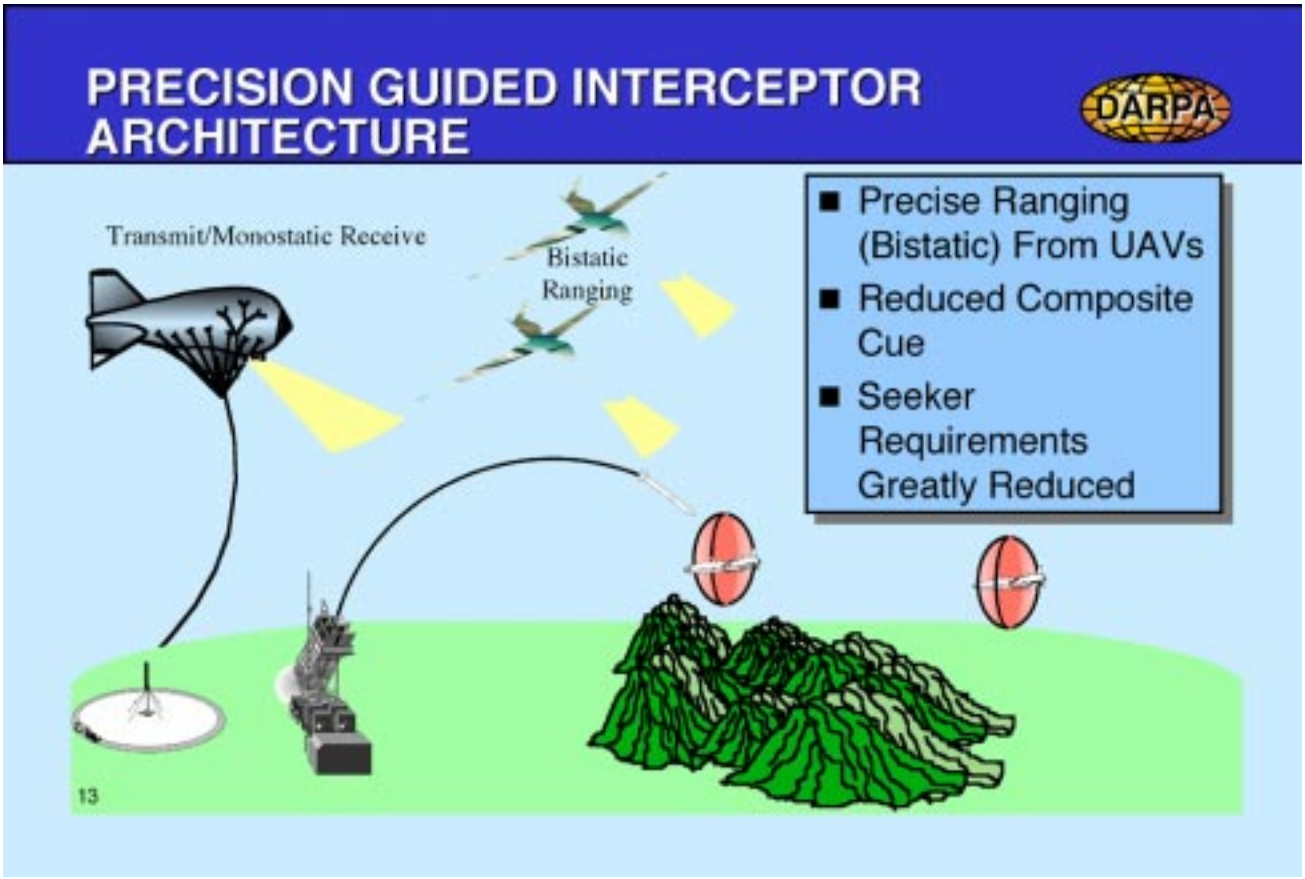
I would now like to give a brief description of the weapon system concepts that are currently being studied and a couple of interesting seeker technologies as example component technologies that may have applicability to LCCMD. The first involves a low cost, long range, subsonic interceptor which can be either ground launched from a Patriot tube or air launched from fighters. In the fighter case up to 18 of these interceptors can be carried. The interceptor takes advantage of the modestly maneuvering threat to operate subsonically and uses the SENGAP engine technology currently being employed in the Miniature Air Launched Decoy (MALD) program. The long range allows interceptors to be deployed on CAP stations on warning. Critical issues in this architecture are subsonic interceptor performance envelopes and the ability to develop a much lower cost active seeker alternative by leveraging microelectromechanical switch technology.



Microelectromechanical switch technology has the promise of offering the radar designer a low loss, low cost, low power approach to building phase shifters. When employed in a low power phased array, it may be possible to greatly reduce the number of MMIC T/R chips required and simplify the antenna manifolding, thereby reducing the total cost. This chart shows an example of a Ka-band, MEMS-based ESA built up from 16 element slats with MEMS phase shifters behind each radiating element, fed by a single MMIC T/R chip. A number of similar concepts are being evaluated at X-band and Ka-band, which offer the promise of up to 75 percent cost reductions versus conventional seekers.

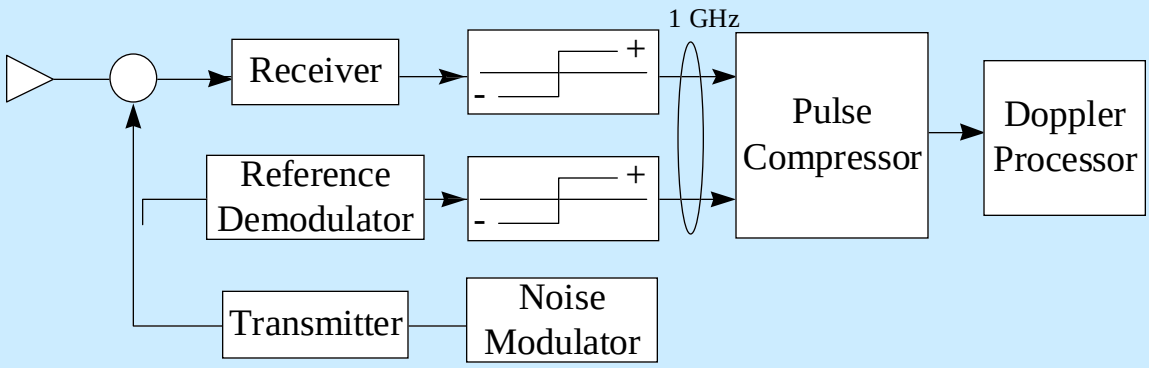


This next concept can be thought of as a “poor man’s uninhabited tactical vehicle.” The notion here is to outfit a recoverable drone with low cost fire control sensors and kill mechanisms to allow it to semi-autonomously engage incoming cruise missiles at long range. The weapon system would be attached to existing SAM fire units, with drones being launched based on a long range cue. The drone is then command guided to the intercept region where an onboard sensor acquires the target. In addition to an acquisition sensor, the drone could be equipped with an imaging sensor that could provide images back to a control station for real time IFF in favorable geometries. The system would employ a low cost kill mechanism such as a modified Stinger or an air-to-air gun to engage the targets. Once a target is negated, the drone could be retargeted, commanded to loiter, or brought back for parachute recovery and repair for the next mission. One of the challenges in this concept is the cost of integration of this weapon into the force structure. Specific issues include O&S costs, overall weapon system combat ID, and data link requirements.



As I mentioned earlier, one of the primary cost drivers in air defense interceptors is the seeker. One potential method of driving overall architecture cost down is to reduce seeker requirements by placing the burden on the fire control system to provide a very precise cue. In the limit, one could envision a command guided interceptor; if the fire control system was sufficiently accurate, the interceptor had an appropriately sized warhead, and the target was not aggressively maneuvering. One method for deriving a very precise cue is depicted in this chart. This concept combines the monostatic sensor information of an airborne fire control sensor with bistatic ranging information from modified UAV sensors to provide a very precise cue to an interceptor. The composite cue could greatly reduce the interceptor required homing range, thereby reducing the seeker detection range requirement and the seeker cost. A number of issues must be and are being addressed before this approach can be considered a viable low cost approach. Extensive UAV radar and/or data link modifications could disqualify this approach as low cost. Robustness to data link latencies, data dropouts, target maneuver and ECM is also being evaluated. Finally, the complexities involved in bias removal and waveform selection to avoid clutter are being studied.

LOW COST SEEKER TECHNOLOGIES - NOISE RADAR



- Features: Wideband (1 GHz), No Ambiguities, High Time-Bandwidth Product
- Reduced Requirements: Antenna Sidelobes, H/W Stability, A/D (1 Bit)
- Challenge: Signal Processor Power Consumption and Packaging

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In addition to the MEMS ESA seeker, another low cost seeker technology is being developed under low cost CMD; the noise radar seeker. This radar uses a wideband noise waveform with long coherent dwells to create a high time-bandwidth product system with a thumbtack ambiguity function. The radar uses a simple noise modulator to drive the transmitter. The transmitted signal is captured on the way out and sampled with a 1 bit A/D or comparator. The return signal is also sampled and then enters the signal processor where very long, high speed correlations are done. Finally, conventional Doppler processing occurs. The lack of ambiguities and the wide bandwidth of the noise radar serve to reduce the requirements on antenna sidelobes due to sidelobe clutter and the hardware stability requirements due to clutter leakage. Additionally, the use of 1 bit A/Ds helps reduce radar cost as compared to a conventional, look-down, pulse Doppler seeker. The challenge here lies in the development of special purpose, packagable signal processors to perform the pulse compression/correlation function. This system also offers the features of rapid, unambiguous range Doppler imaging and inherent ECM robustness which may be of use for a variety of missions.

INDUSTRY OPPORTUNITIES

- Novel LCCMD Approaches
- BAA To Be Released For Low Cost Seeker Technologies To Counter Asymmetric Threats
  - Low Cost Cruise Missiles, UAVs, Jammers

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We continue to keep a sharp eye out for promising LCCMD approaches. We don't currently envision another BAA, however, that may change once we near the end of the current round of concept evaluations. We will be releasing a BAA within a few months for low cost seeker technologies to counter the class of asymmetric threats that I outlined earlier: low cost cruise missiles, UAVs, and jammers. Innovative active, passive, RF, and EO solutions will be sought.